



technology opportunity

PseudoDiversity—Direct Wavefront Control and Image Restoration at High Bandwidth



NASA Goddard Space Flight Center (GSFC) invites companies to license an innovative approach for recovering wavefront data that provides accurate and precise alignment for optical systems. PseudoDiversity is a direct-solve, non-iterative approach that can be implemented at low cost and in low-power hardware. The system, while running in a closed-loop, maintains high image quality while simultaneously controlling the optical system. It has the advantage of no extraneous hardware and uses the same optical path as the optical instrument, eliminating the introduction of non-common path errors.

Benefits

- **Fast:** Requires no iterative algorithms and increases speed over previous approaches to only fractions of a second.
- **Broadband:** Requires no narrowband, photon-limiting spectral filters or diffraction gratings, making optimal use of all the input light
- **Accurate:** Uses the same optical path as the science instrument, eliminating errors due to non-common paths
- **Simplifies system:** Requires no additional components, reducing cost and complexity and simplifying system needs
- **Continuous observation:** Alignment and control take place simultaneously with image acquisition within a closed loop and are limited only by the speed at which the camera can frame out an image
- **Low power:** Can be implemented in low-power hardware

Applications

PseudoDiversity is useful for both astronomical and Earth-based sensing rapid and well-corrected images are required and has potential for spectroscopic systems.

- Remote sensing for:
 - Aircraft
 - Space sensors
 - Missile targeting
- Sensing of atmospheric turbulence
- Gun sights for targeting laterally through the atmosphere for tanks and other military vehicles
- Medical imaging (e.g., imaging through viscous media such as cells)
- Microscopy

Technology Details

Typical segmented and sparse aperture systems recover the wavefront (needed for active and adaptive optical control) using deformable mirrors and actuators to move and deform the optics. Using phase retrieval and phase diversity approaches, one generally introduces artificial, but known, phase errors (typically focus) and iterative, nonlinear algorithms are applied to solve for wavefront errors. These conventional algorithms often have problems with convergence, stagnation, and are non-deterministic in time (i.e., it is impossible to predict prior to execution how many iterations it takes to converge). This process is complex and computationally time consuming, requiring specialized personnel, computers, and hardware.

How it works:

With this new PseudoDiversity approach, alignment and control of the optical system takes place in a closed loop simultaneously with image acquisition; diversity is introduced in a natural fashion by exploiting the spatial and temporal correlations introduced by the resolution of the sensor. Conceptually, by temporally modulating sets of segments or apertures at different frequencies, focal plane images are sequentially detected with known or separable temporal dependencies. In PseudoDiversity, the temporal modulation occurs naturally as part of the control process since the commanded actuator motion is known from the previous history of time steps. Processing this time sequence of images enables the detection of wavefront errors that are then fed back to the actuators to correct them. Errors that are not corrected by the actuators are algorithmically corrected in the image.

PseudoDiversity works on any segmented, sparse, or interferometric aperture system, and it works whether or not the aperture is redundant or non-redundant. By exploiting spatial, temporal, and spectral correlations in the image as a function of time, PseudoDiversity builds up and integrates phase-corrected spatial frequencies of the

image—resulting in simultaneous recovery of both the high-resolution object and wavefront errors that are fed back to control the actuators. The result is a high-resolution image sequence as a function of time.

Why it is better:

Traditional systems use complex metrology systems that often introduce their own errors. PseudoDiversity requires no additional hardware and uses the same optical path as the target under study, eliminating the introduction of non-common path errors (i.e., PseudoDiversity recovers the wavefront as seen through the instrument). It works faster, taking fractions of a second rather than minutes to solve, and it requires no narrowband, photon-limiting spectral filters or diffraction gratings.

Patents

NASA Goddard Space Flight Center is seeking patent protection for the technology.

Licensing and Partnering Opportunities:

This technology is part of NASA's Innovative Partnerships Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the PseudoDiversity – Direct Wavefront Control and Image Restoration at High Bandwidth (GSC-15464-1) for commercial applications. For information and forms related to the technology licensing and partnering process, please visit the Licensing and Partnering page on Goddard's IPP Office Web site: <http://ipp.gsfc.nasa.gov/lic-partnerships.html>.

For More Information

If you are interested in more information or want to pursue transfer of this technology (GSC-15464-1), please contact:

Innovative Partnerships Program Office
NASA Goddard Space Flight Center
techtransfer@gsfc.nasa.gov
<http://ipp.gsfc.nasa.gov>